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CONTROL OF CATERPILLARS

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On Commercial Cabbage
and Other Cole Crops
in the Sun

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CURRENT SERIAL RECORDS

- Cabbage
- Broccoli
- Cauliflower
- Collards
- Kale

Farmers' Bulletin
No. 2099

UNITED STATES DEPARTMENT OF AGRICULTURE

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Control of Caterpillars

on Commercial Cabbage and Other Cole Crops in the South

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The feeding of caterpillars on cabbage and other cole crops reduces the income of southern growers by millions of dollars each year. The losses are accounted for in part by damaged crops—lower yields and lower quality—and in part by the cost of combating these insects.

Cole crops other than cabbage that are attacked by caterpillars in the South are broccoli, cauliflower, collards, and kale. Brussels sprouts and kohlrabi are also attacked by caterpillars, but are not grown extensively in the South.

The caterpillars can be controlled by applying insecticides, but no single insecticide will control all of them. In order to select effective insecticides, you must be able to identify the caterpillars attacking your crop.

THE CATERPILLARS AND HOW THEY DAMAGE PLANTS

At least 13 kinds of caterpillars damage cabbage and other cole crops in the South. They can be grouped according to their destructiveness:

1. *Those causing major damage throughout the South.*—They are the cabbage looper, the imported cabbageworm, larvae of the dia-

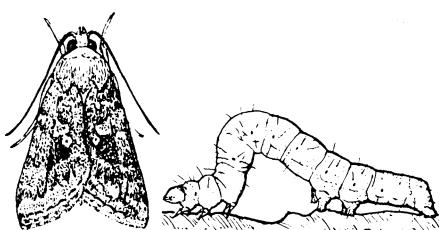
mondback moth, the corn earworm, and several species of cutworms.

2. *Those causing serious damage in some parts of the South.*—They are the cabbage webworm, the cross-striped cabbageworm, and the fall armyworm.

3. *Those causing only occasional and usually minor damage in the South.*—The southern cabbage-worm, the Gulf white cabbageworm, the salt-marsh caterpillar, and a few others are in this group.

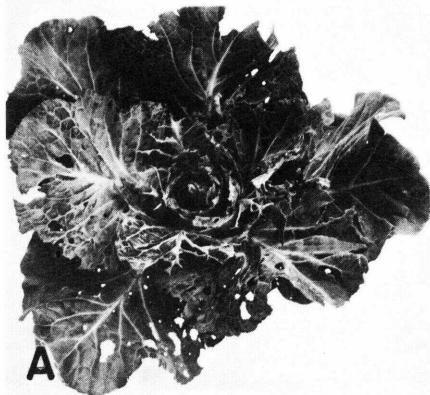
Cabbage Looper

The cabbage looper usually is the most destructive of the caterpillar pests of cole crops in the South. It is the caterpillar of a medium-size, grayish-brown moth. The moths have a silvery spot near the middle of each of the front wings that looks like a figure 8.

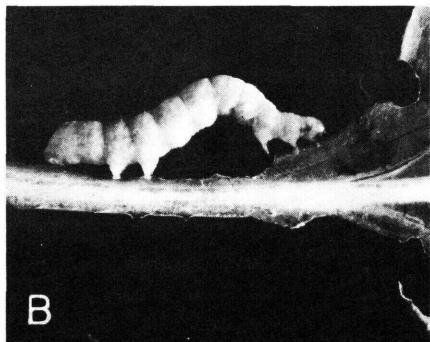


TC-3851

Figure 1.—Adult and larva of the cabbage looper.



A



B

TC-7009, TC-4012B

Figure 2.—Injury caused by cabbage loopers: A, Typical injury to center part of a cabbage plant. B, Full-grown looper feeding on a leaf. Note the characteristic notches along edges of the leaf.

The moths ordinarily fly near the ground and are most active at night. They have a wingspread of $1\frac{1}{4}$ to $1\frac{1}{2}$ inches.

The moths lay their greenish-white eggs singly. They lay the eggs chiefly on the lower surfaces of the outer leaves of the plants. The eggs are smaller than a pin-head, are ridged, and are almost round.

When first hatched, the caterpillars have dark heads and almost colorless bodies. They later become pale green, and have several whitish, lengthwise stripes that fade considerably as the caterpillars

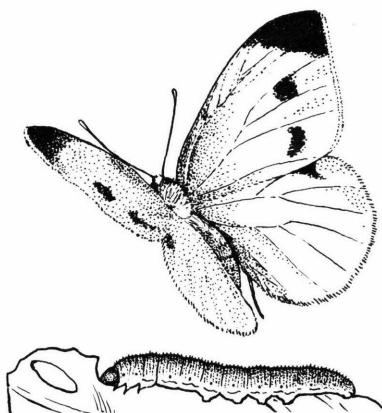
grow. When mature, the caterpillars are about $1\frac{1}{2}$ inches long. They crawl by doubling up, or forming a loop, then projecting the front part of the body forward.

Pupae are copper colored. They are encased in loosely woven cocoons that are attached to a leaf on the plant, a fallen leaf, or debris near the base of the plant.

Newly hatched cabbage loopers usually eat out small areas on the underside of plant leaves. As the caterpillars become larger, they move nearer to the center of the plant and eat entirely through the leaves between the veins, or feed inward from the edges of the leaves. Large loopers are heavy eaters and usually cause serious damage to the marketable portion of the plants.

Imported Cabbageworm

The imported cabbageworm sometimes called the common cabbageworm, is the caterpillar of a yellowish-white butterfly. The butterflies have several black spots on their wings, have a wingspread of about 2 inches, and are frequently seen flying in and near plantings of cole crops.

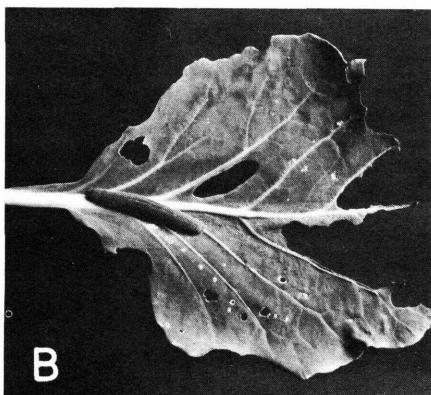


TC-3851

Figure 3.—Adult and larva of the imported cabbageworm.



A



B

TC-4010, TC-9010

Figure 4.—Injury caused by imported cabbageworms: A, Typical injury to center part of a cabbage plant. B, Imported cabbageworm on leaf.

The butterflies lay eggs singly on either side of the leaves of cole crops. The eggs are yellow, oblong, bluntly pointed at the ends, deeply ridged lengthwise, and attached by one end.

The caterpillars are velvety green. They have a narrow, orange stripe down the middle of the back and a broken, yellowish stripe along each side of the body. When mature, they are about $1\frac{1}{4}$ inches long.

Pupae may be green, grayish green, or tan. They have sharp, angular projections in front and along the back, and a tough cover-

ing. They are attached by a silklike thread to a leaf of a host plant or to some other object in or near the field.

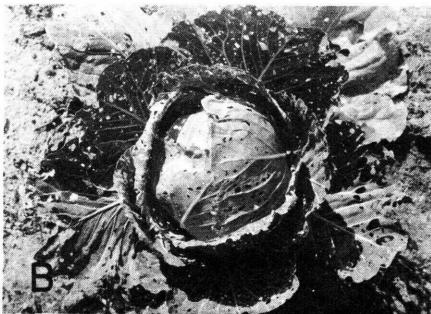
Imported cabbageworms cause plant injury similar to that of cabbage loopers, but they are more likely to eat through the smaller veins of the leaves. They also feed nearer to the center of the plant, and do more damage to the edible part.

Larvae of the Diamondback Moth

Diamondback moths are about one-third inch long, have a wing spread of less than an inch, and are gray. The males have three light-yellow, diamond-shaped markings on their wings. The moths move



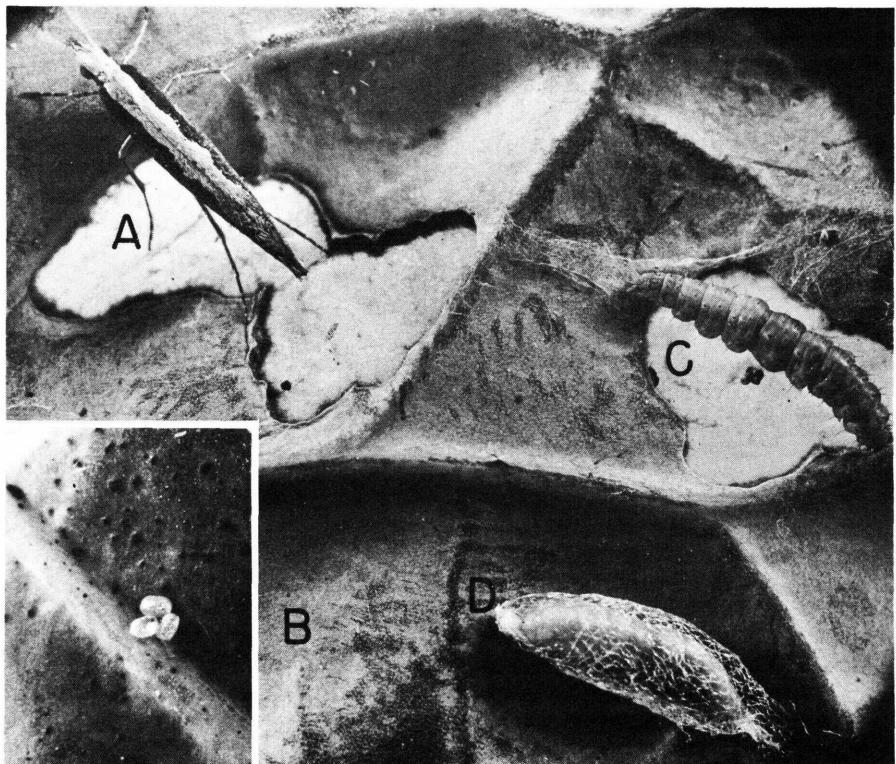
A



B

TC-7253, TC-7254

Figure 5.—Injury caused by larvae of the diamondback moth: A, Young cabbage plant with badly injured bud. B, Typical injury to an older plant.



TC-7013, TC-7014

Figure 6.—The diamondback moth; A, Female moth with wings folded. B, Eggs. C, Larva. D, Pupa.

rapidly when disturbed. They fly short distances from plant to plant during the daytime.

Female moths lay eggs on cole crops, singly or in groups of 2 or 3. They lay the eggs on the leaves or on the stalk near the terminal bud. The eggs are small, almost round, and yellowish white.

The larvae are light green and slightly pointed at each end. Their bodies are covered with tiny, erect, black hairs. When mature, they are about one-third inch long. They wriggle rapidly when disturbed, often dropping from the plant and hanging by silklike threads.

The larvae of the diamondback moth feed on all parts of the plant,

but they prefer places around the bud of a young plant, crevices between loose leaves of a firm head, and the underside of lower leaves. Their feeding may disfigure the bud of a young plant so that the head or other marketable portion will not develop properly.

The pupae are encased in loosely woven, gauzelike cocoons that are fastened to the leaves of the host plant or in crevices near the plant bud.

Corn Earworm

The corn earworm is also known as the tomato fruitworm or the cotton bollworm. It is the caterpillar

of a night-flying moth that has a wingspread of about $1\frac{1}{2}$ inches. The moths vary in color from light olive green to grayish brown or yellowish brown.

Female moths lay their eggs on the leaves of cole crops or on grasses nearby. The eggs are ribbed, shaped like a flattened ball, and light yellow to dusky brown.

Newly hatched corn earworms are whitish and have black heads. The older ones are green, greenish brown, or greenish black; they are usually marked with stripes of yellow, brown, green, and black; they have yellow heads. Full-grown earworms are about $1\frac{1}{2}$ inches long.

Mature caterpillars burrow 2 to 6 inches into the soil and transform into shiny, light brown pupae about three-fourths inch long.

A single corn earworm may seriously damage or destroy the bud of a cole crop plant, causing the plant to be disfigured or to produce several secondary buds. Earworms may disfigure the heads of cabbage plants by their feeding and tunneling.

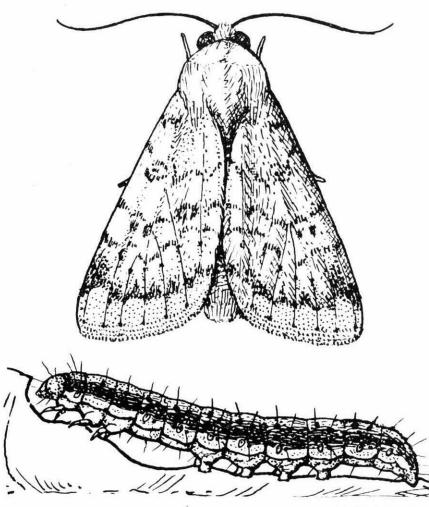
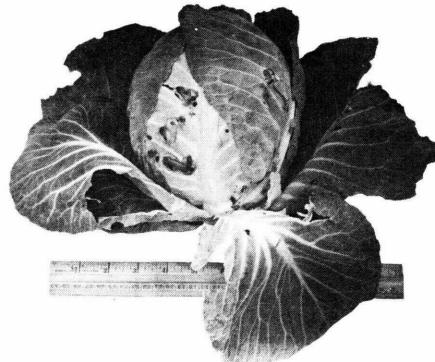


Figure 7.—Adult and larva of the corn earworm.



TC-7036

Figure 8.—Cabbage head damaged by the corn earworm.

Cutworms

Several species of cutworms, including the black cutworm, the variegated cutworm, and the granulate cutworm, attack cabbage and related crops in the South.

Cutworms are the caterpillars of night-flying moths. The moths range in color from gray to brown and have varied designs of stripes and spots. They have a wing-spread of about $1\frac{1}{2}$ inches.

The moths lay their eggs on the leaves of grasses, weeds, and other host plants, and sometimes on bare ground.

The cutworms are smooth skinned and somewhat shiny. They range in color from gray to brown and almost black. Some of them have distinctive markings of stripes and spots.

The shiny, brown pupae are about three-fourths inch long and are found underground.

Cutworms feed mostly at night and hide during the daytime on or just below the soil surface. They cut off the stalks of young plants; they also feed on the leaves, buds, and heads.



TC-2935

Figure 9.—Young cabbage plant whose stalk and leaves were cut off by a cutworm.

Cabbage Webworm

The cabbage webworm is the caterpillar of a moth that has front wings of brownish yellow mottled with darker brown, and hind wings of pale gray. The moths have a wingspread of a little more than one-half inch. When disturbed in the field, the moths make short, uneven flights, and come to rest quickly among the leaves of a plant or on the ground, where their color blends with that of the soil.

Female moths lay grayish-white eggs near the buds of young host plants. As the plants approach maturity, the moths prefer to lay their eggs on the underside of a leaf in the angle along the leaf stems.

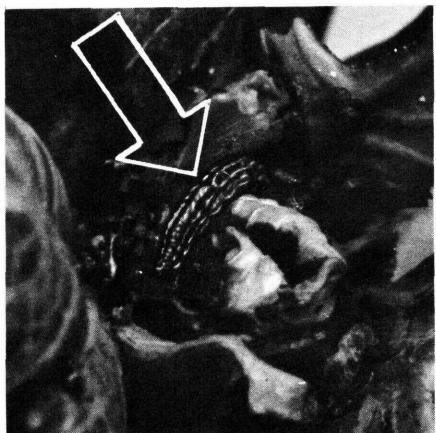


TC-7016

Figure 10.—Cabbage webworms, approximately full grown.

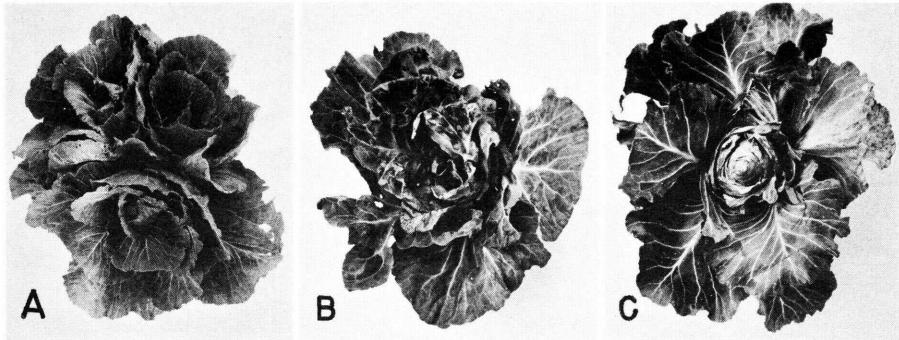
The webworms are about one-half inch long when mature. They are dull grayish yellow, and marked with five conspicuous brownish-purple lengthwise stripes. Their heads are black and bear a V-shaped mark.

When first hatched, the caterpillars feed on either side of the partly folded leaves of the plant bud. After a few days, the caterpillars begin to feed beneath a protecting web made from silklklike threads that



TC-7017

Figure 11.—Cabbage webworm feeding on the bud of a young cabbage plant. To show it, the web was removed and the leaves were partly unfolded.



TC-7018, TC-7020, TC-7019

Figure 12.—Cabbage webworm injury to cabbage plants: *A*, Multibudded plant resulting from earlier destruction of the terminal bud. *B* and *C*, Plants with disfigured buds caused by earlier feeding by webworms.

they secrete. Sometimes the caterpillars are found on the outer leaves or along the main ribs of leaves and along the main plant stalk in a leaf axil. They can be detected by the debris and the webs at the point of feeding.

The shiny, light brown pupae are about one-fourth inch long. They are formed in a web that is attached to fallen leaves and other debris on the soil surface.

Cabbage webworms tunnel into and kill the buds of young plants of cabbage and related crops. One webworm can ruin a young plant. Destruction of the original bud causes the production of secondary ones that rarely develop into firm heads by harvesttime. Less severe injury may disfigure the head produced from the original bud. Feeding of this insect on the outer leaves of older plants usually does little harm.

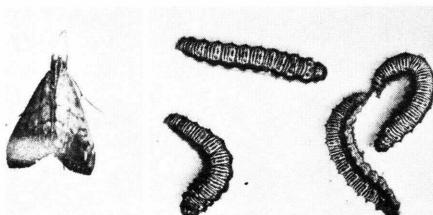
Cross-Striped Cabbageworm

The adult of the cross-striped cabbageworm is a moth that has a wingspread of about 1 inch. The front wings are mottled yellowish brown to brown, and are marked with zigzag lines of dark brown. The hind wings are lighter in color

than the front wings. They are almost transparent at the base, darker at the front, and marked across the free end with a row of 5 or 6 small, indistinct dusky spots.

The female moths lay eggs on the underside of the leaves of cole crops in masses of 20 to 30. The eggs overlap one another like shingles on a roof. The eggs are light yellow and semitransparent.

When first hatched, the cabbage-worms, or caterpillars, are gray. They are about three-fifths inch long when full grown and have numerous tiny black stripes across bluish gray backs. Along each side of the back is a black stripe; below the black stripe on each side of the body is a bright yellow stripe. The underside of the body is light green, mottled with yellow.



TC-7029, TC-7070

Figure 13.—Adult and larvae of the cross-striped cabbageworm.



TC-7031

Figure 14.—Cabbage plant injured by the cross-striped cabbageworm. Note that the ends of the leaves are not eaten off as in figures 2, A and 4, A and that the holes are smaller.

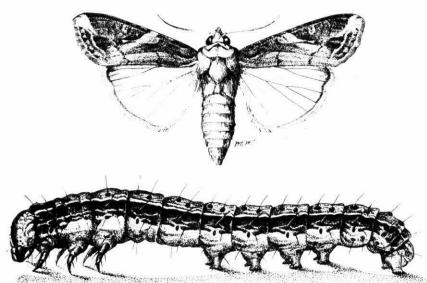
The caterpillars enter the soil and pupate just below the soil surface in a tight cocoon. The pupae are about one-half inch long and light yellowish brown to dark brown.

Cross-striped cabbageworms prefer the tender terminal buds and the heads of cole-crop plants; they riddle them with holes. Because the eggs are laid in clusters, large numbers of the caterpillars hatch on individual plants scattered over a field.

Fall Armyworm

The fall armyworm is the caterpillar of a night-flying moth that has a wingspread of about $1\frac{1}{2}$ inches. The body of the moth is ash

gray. Forewings of the male are dark-gray ground color and have a mottled appearance; they usually have an irregular white or light-



C & F-488

Figure 15.—Adult and larva of the fall armyworm.

gray spot near the tip. Forewings of the female usually are darker than those of the male. Hind wings of both sexes are white; they have a pearly or pinkish luster, and are edged with a smoky-brown line.

The eggs are light gray, are covered with a grayish down that comes from the body of the moth, and are laid in clusters of 50 or more, usually on blades of grass.

When first hatched, the caterpillars are grayish white and have jet-black heads. Full-grown fall armyworms are about 1½ inches long. They have lighter colored heads than when newly hatched. They have few hairs on their bodies, which are striped and light green to almost black. They have a black band on each side of the body and usually have a whitish inverted Y marking on the front of the head.

The pupae are shiny, reddish to almost black, and about three-fourths inch long. They are formed 1 or 2 inches underground.

Fall armyworm damage to cabbage and related crops occurs chiefly

when the plants are small. The injury is similar to that caused by the cabbage looper.

Southern Cabbageworm

The southern cabbageworm is the caterpillar of a white butterfly that looks like the adult of the imported cabbageworm, except that it has more checkered black spots.

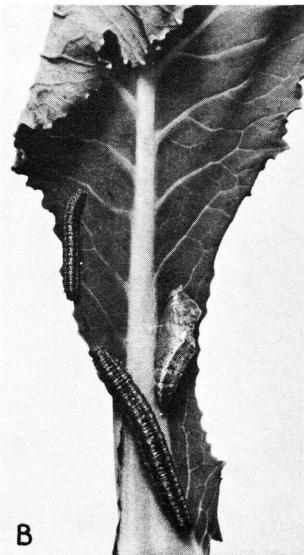
The caterpillars are about 1 inch long. Their color ranges from bluish to purplish to green. They are marked with four yellow stripes lengthwise on the body, and with small black dots.

The pupae are bluish green and spotted. In shape, size, and location they are similar to pupae of the imported cabbageworm.

The injury to cabbage is similar to that caused by the imported cabbageworm.

Gulf White Cabbageworm

The Gulf white cabbageworm is the caterpillar of a white butterfly



TC-7272, TC-7273

Figure 16.—The southern cabbageworm: A, Adults—male (left) and female. B, Larvae and pupa on cabbage leaf.

that looks like the adult of the imported cabbageworm.

The caterpillars are 1½ inches long when mature. They are yellow and have four purplish stripes.

Gulf white cabbageworm injury to cabbage and related crops is similar to that caused by the imported cabbageworm.

Salt-Marsh Caterpillar

Salt-marsh caterpillars are the larvae of a white moth that has yellow and black markings on the abdomen and black dots on the wings.

The larvae belong to a group of insects known as woolly-bear caterpillars. They are 1½ to 2 inches long when full grown. The bodies of salt-marsh caterpillars are partly covered by long reddish-brown to black hairs that give them a woolly appearance.

The pupae are found under trash, dead leaves, and other shelter on top of the soil. They are in thin silken cocoons covered with interwoven hairs from the body of the caterpillar.

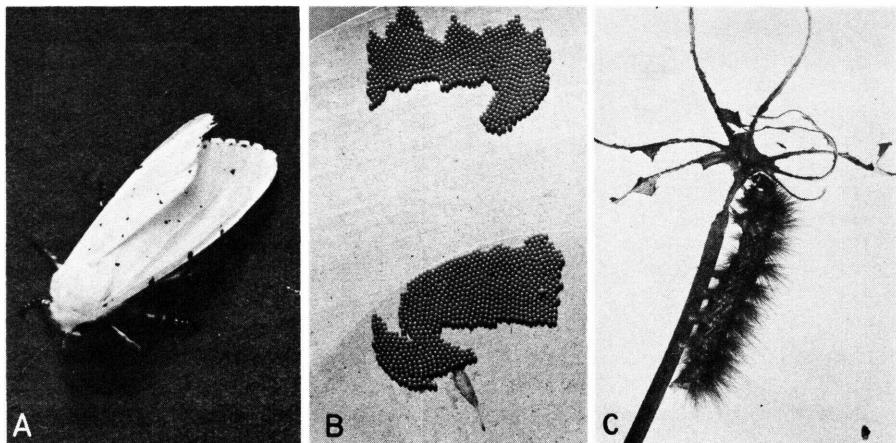
Salt-marsh caterpillars feed on the outer leaves of cole crops, espe-

cially on plants near outer margins of the field. The injury is similar to that caused by the cabbage looper.

WHEN AND WHERE THEY OCCUR

Caterpillars may injure winter plantings of cole crops in Florida and southern Texas at any time during an average winter. They attack summer plantings in mountainous sections during the summer and early fall. They are usually most destructive during the spring and fall in other sections of the South.

Winter crops in Florida and southern Texas are injured by imported cabbageworms, cabbage loopers, cabbage webworms, corn earworms, cutworms, and larvae of the diamondback moth. Diamondback moth caterpillars develop at lower temperatures than most other cabbage caterpillars and are favored by mild, dry winter and spring seasons. The Gulf white cabbageworm appears to be a serious pest in the South only in southern Florida, where it is the most common



TC-7274

Figure 17.—The salt-marsh caterpillar: A, Adult female moth. B, Egg masses. C, Caterpillar.



TC-7285, TC-7257

Figure 18.—Effect of insecticide in the control of the cabbage looper, the imported cabbageworm, and larvae of the diamondback moth on cabbage: A, Plants treated with insecticide before the heads began to form. B, Untreated plants in the same field.

caterpillar on cabbage and collards in late spring and early summer.

Winter-spring plantings of cole crops in such areas of the South as coastal South Carolina and Baton Rouge, La., usually are not seriously injured by caterpillars during mid-winter and early spring. A few cabbage loopers, cutworms, and larvae of the diamondback moth often are present, however, and sometimes cause considerable damage when the weather is unusually mild. Later plantings—those harvested in April and May—usually are seriously injured in these areas by the cabbage looper, the imported cabbageworm, and the larvae of the diamondback moth. Populations of these caterpillars ordinarily increase rapidly, and control measures usually are needed on spring plant-

ings in these areas when weekly mean temperatures reach 60° F. for 3 consecutive weeks.

Summer-grown crops in the mid-South, especially those grown in the mountains of western North Carolina, northern Georgia, and southwestern Virginia, may be injured by cabbage loopers, imported cabbageworms, cross-striped cabbageworms, and cutworms. Larvae of the diamondback moth sometimes injure these plantings, and cabbage webworms may appear in late summer and fall.

Fall plantings seeded directly in the field in the mid-South may be injured by caterpillars from the time they come up until temperatures are consistently below 50° F. Such temperatures usually occur after mid-November around Baton

Rouge, La., and Charleston, S.C. Short cold periods, even though frosts and freezing temperatures may occur, only cause the caterpillars to seek protected places in the plants. Fall plantings are usually subject to severe injury by cabbage webworms, cutworms, fall armyworms, cabbage loopers, corn earworms, and imported cabbage-worms. Cutworms and fall armyworms are especially abundant when grass is grown in a field before cabbage is planted or is allowed to grow with cabbage or other cole crops. Corn earworms often feed on fall cabbage when corn is no longer available. Larvae of the diamondback moth often appear on fall crops while they are being harvested.

In general, weather conditions favorable to the growth of cole crops also favor the development of caterpillars.

Caterpillars do not thrive when temperatures are extremely high or low, or when there is severe drought or heavy rainfall. Excessive rainfall is particularly unfavorable to the larvae of the diamondback moth. Caterpillars usually are inactive when the temperature is below 50° F.

Frequent summer and fall rains cause rapid growth of grasses in cabbage fields; this increases the number of fall armyworms and cutworms.

CONTROL WITH INSECTICIDES

Insecticides are usually necessary to control caterpillars on cabbage and other cole crops. Not all kinds of caterpillars can be killed with a single insecticide, and several kinds of caterpillars may appear at the same time.

Crops grown late in the spring, during the summer, and in the fall

usually require the greatest number of applications and the highest dosages of insecticides. Plantings grown in southern Florida and Texas during the winter also require insecticide control measures.

Selection of the Insecticide

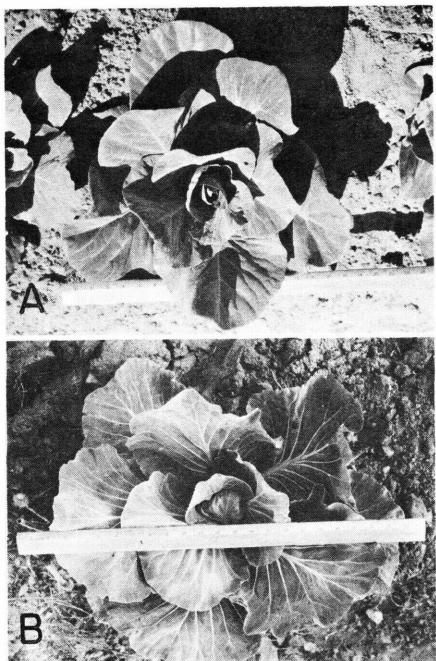
The kind of insecticide to use depends on the kinds of caterpillars present, and on whether the plants have begun to form the parts that are to be eaten or marketed.

Insecticides that are most effective against cabbage caterpillars leave residues that may persist for a long time on the parts of the plant on which they are applied. Toxaphene and DDT should not be applied after the portions of the plants to be eaten or marketed begin to form (fig. 19). With certain restrictions (see pp. 17 and 18), endosulfan (Thiodan), parathion, naled (Dibrom) can be used after appearance of parts to be eaten.

Bacillus thuringiensis can be applied at any time during the growth of broccoli, cabbage, or cauliflower. Do not use it on any other cole crop.

Marketing practices in most areas in the South usually permit use of toxaphene and DDT on cabbage, broccoli, and cauliflower until 30 to 35 days before harvest begins. Use of these materials on cabbage to be marketed with more than 4 loose, or "wrapper" leaves, on cabbage to be harvested before the heads become hard, and on other cole crops may have to be discontinued as long as 60 days before harvest.

To obtain best results in controlling caterpillars with insecticides you should: (1) Watch the crops closely to find out when caterpillars appear and what kinds are present; (2) begin applying the right insec-



TC-2453, TC-2175

Figure 19.—The use of endosulfan, DDT, and toxaphene on cabbage that is to be marketed with four wrapper leaves should be discontinued when the heads begin to form. Plants in this stage of development are shown above: A, Plant of the pointed-head type (Charleston Wakefield variety), B, Plant of the roundhead type (Copenhagen Market variety).

ticide at once; (3) try to have the plants free of caterpillars, especially cabbage webworms, when thinned or transplanted, and try to have them free of cabbage loopers and corn earworms when the marketed parts of the plants become exposed; and (4) apply toxaphene or endosulfan just before the marketable portions of the plants appear (see fig. 19) even though few caterpillars are present. Preventive applications should be made at this time because the insecticides that can safely be applied later will not control the corn earworm, cutworms, the salt-marsh caterpillar, or the fall armyworm, and are only

partially effective against other kinds of caterpillars.

The cabbage looper has become quite resistant to DDT throughout the South, and at least moderately resistant to toxaphene in some areas. Endosulfan usually is effective against this insect, but should be used only on cabbage, broccoli, and cauliflower. Parathion and naled usually give only partial control of high populations, especially during hot weather. A mixture of toxaphene and parathion is sometimes needed for control of the cabbage looper.

The imported cabbageworm also has become difficult to control with DDT, but can be satisfactorily controlled with toxaphene, parathion, naled, and *Bacillus thuringiensis*. Endosulfan is only partially effective against high populations of this insect and the fall armyworm.

DDT will control the corn earworm and certain other kinds of caterpillars, but usually will not provide adequate protection when used alone. When toxaphene is being used and the corn earworm becomes a problem, as it may during the fall, DDT can be used in combination with the toxaphene or can be applied separately.

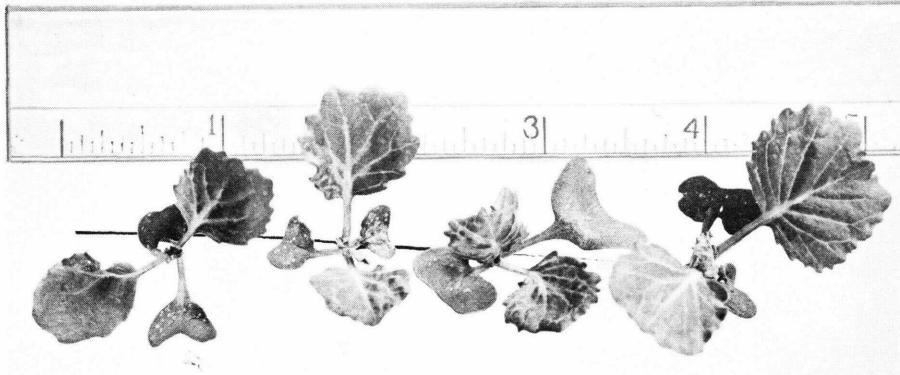
Consult your State agricultural experiment station or county agricultural agent for the latest developments on the control of cabbage caterpillars.

Use table 1 on page 16 as a guide for the selection and use of insecticides in the control of the more destructive caterpillar pests of cabbage and related crops. Table 2 on page 20 gives effective formulations and dosages of the insecticides. Dusts, wettable powders, or emulsifiable concentrates of different strengths than those in table 2 may be used if they are applied at a rate that will provide the recommended dosage of the active ingredient.

TABLE 1.—*Guide for selection and use of insecticides for caterpillar control on cole crops*
 [For restrictions on the use of these insecticides see pages 14-21]

Insect	Insecticides ¹	Timing of application
Cabbage looper	Before portion to be marketed appears	After portion to be marketed appears
Imported cabbageworm Diamondback moth larvae	Toxaphene plus parathion, endosulfan (Thiodan) plus parathion, toxaphene, or endosulfan	Parathion, endosulfan, or naled (Dibrom). These materials may not give adequate control of the cabbage looper under some conditions. <i>Bacillus thuringiensis</i> will control the imported cabbageworm and the cabbage looper.
Cross-striped cabbageworm Gulf white cabbageworm Southern cabbageworm	Toxaphene, parathion, or endosulfan	Toxaphene or parathion
Cabbage webworm	Toxaphene or parathion	-----
Corn earworm Salt-marsh caterpillar Climbing cutworms Fall armyworm	DDT Toxaphene Toxaphene	Begin on summer or fall plantings when first true (crinkly) leaf appears (fig. 20); repeat once or twice at weekly intervals.
Soil-inhabiting cutworms	Toxaphene or DDT	Begin when caterpillars first appear; repeat every 7 to 10 days.
		Apply to soil as needed.

¹ Use endosulfan and *Bacillus thuringiensis* on broccoli, cabbage, and cauliflower only. Do not use naled on kohlrabi.



TC-7058

Figure 20.—Cabbage plants just beyond the stage of growth at which cabbage worm control measures should begin.

Precautions

Insecticides used improperly can be injurious to man and animals. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the labels.

Some States have special restrictions on the use of certain insecticides. Before applying insecticides, check State and local regulations.

Keep insecticides in closed, well-labeled containers in a dry place. Store them where they will not contaminate food or feed, and where children and animals cannot reach them. Promptly dispose of empty insecticide containers; do not use for any other purpose.

When handling an insecticide, wear clean, dry clothing.

Avoid repeated or prolonged contact of insecticide with your skin.

Wear protective clothing and equipment if specified on the container label. Avoid prolonged inhalation of insecticide dusts or mists.

Avoid spilling an insecticide concentrate on your skin, and keep it out of your eyes, nose, and mouth.

If you spill any on your skin, wash it off immediately with soap and water. If you spill any on your clothing, remove the clothing immediately and wash the skin thoroughly. Launder the clothing before wearing it again.

After handling an insecticide, do not eat, drink, or smoke until you have washed your hands and face. Wash any exposed skin immediately after applying an insecticide.

DDT can be used without special protective clothing or devices, provided it is in diluted dust or water spray form.

Endosulfan, naled, and toxaphene can be absorbed directly through the skin in harmful quantities. Dilutions of these insecticides should be handled with the same precautions as with concentrates.

NOTE.—A current list of acceptable protective respiratory devices may be obtained from the Information Division, Agricultural Research Service, USDA, Hyattsville, Md. 20782.

Parathion is highly toxic and may be fatal if swallowed, inhaled, or absorbed through the skin. It should be applied only by a person thoroughly familiar with its haz-

ards and who will assume full responsibility for safe use and comply with all the precautions on the labels.

If you must transplant or otherwise handle plants within 5 days after treatment with parathion, wear clean, dry cotton gloves.

Residues in excess of the established tolerances can be avoided by applying only those insecticides specified for use on the crop and by following indicated schedules. Do not exceed the dosage given in this bulletin. Begin applications in the early stages of plant growth when insect populations are light, and heavy dosages will not be required. Observe carefully the required interval between the last application and harvest, and the other restrictions stated below.

DDT and toxaphene should not be applied to portions of any cole crop to be eaten or marketed.

Do not apply DDT or toxaphene to broccoli after flower buds begin to form; or to cauliflower after the curds are about one-half inch in diameter; or to cabbage after heads begin to form unless all loose or partly loose leaves are removed at harvest. If only the firm heads of cabbage are to be eaten or marketed, DDT may be applied until 14 days of harvest, and toxaphene at dosages up to 2½ pounds of active ingredient per acre may be applied until 7 days of harvest. Do not use DDT within 21 days of harvest on collards and kale intended for processing or after the seedling stage is passed when these crops are grown for fresh green market. Do not use toxaphene on brussels sprouts, collards, kale, or kohlrabi after edible parts start to form or within 35 days of harvest on collards and kale or 30 days of harvest on brussels sprouts or kohlrabi.

Do not apply endosulfan to cauliflower after the edible parts start to form or to broccoli and cabbage within 7 days of harvest. Do not

apply endosulfan on brussels sprouts, collards, kale, or kohlrabi.

Do not apply parathion to broccoli, brussels sprouts, cauliflower, or kohlrabi within 7 days before a harvest; or to cabbage, collards, or kale within 10 days before a harvest. To avoid excess residues of parathion on the plants at harvest and to avoid inadequate insect control during cool weather, do not apply this insecticide unless daily maximum temperatures well above 70° F. are expected for the next few days. If maximum temperatures below 70° persist after application, you should either wait at least an extra week before harvest (over and above the waiting period specified above) or have a chemist check to make sure the residue is below the tolerance of 1.0 p.p.m. If you fail to control the insects at low temperatures do not repeat the parathion application; but use another insecticide instead.

Do not apply naled to kohlrabi at any time and to other cole crops within 4 days of harvest.

Do not feed plants treated with DDT, endosulfan, or toxaphene to poultry or dairy animals or to animals being finished for slaughter.

Avoid drift of insecticide to nearby wildlife habitats, bee yards, crops, or livestock. Do not apply insecticides under conditions favoring drift from the area to be treated.

Many insecticides are highly toxic to fish and aquatic animals. Keep insecticides out of all water sources such as ponds, streams, and wells. Do not clean spraying equipment or dump excess spray material near such water.

Do not apply insecticides to plants during hours when honey bees and other pollinating insects are visiting them.

Dispose of empty insecticide containers at a sanitary land-fill dump,

or bury them at least 18 inches deep in a level isolated place where they will not contaminate water supplies.

Application of Insecticides

Sprays or dusts do not adhere well to plants that are dripping wet with rain or dew. Do not dust or spray just before a rain is expected. Dust or spray again if one-half inch or more of rain falls within 24 hours after an application.

Adjust the nozzles of dusting or spraying equipment so as to direct the insecticide into all parts of the plant and onto both the upper and lower sides of the leaves. Be sure to get good coverage of the growing buds and the marketable portions of the plants.

DUSTING.—The best time for applying most dusts is when the plants are moist but not wet, there is little or no wind, and humidity is high. The desired conditions exist most often after sunset and early in the morning. Night dusting operations, with hand-held lights or lights mounted on the equipment, are usually effective. Early-morning dusting is satisfactory unless the plants are so heavy with dew that the dust runs off when applied to leaves. Morning dusting should be discontinued if the wind rises or the plants become dry.

When cabbage plants are large, especially after the heads begin to form, direct 2 dust nozzles into the sides of each row at an angle of 45 degrees to the soil level. If the duster has only 1 nozzle, make 2 trips per row when dusting large or heading plants.

SPRAYING.—Spraying can be done during a greater part of the day and under more adverse weather conditions than dusting. Sprays for caterpillar control on cabbage may be applied at rates of 20 to 100 gallons per acre. Emulsifiable concentrates are better to use in low-

gallonage sprayers than wettable powders, but are more likely to injure the plants. The wettable powder or emulsifiable concentrate should be thoroughly mixed with the water in the spray tank before spraying begins. It should be kept mixed during the spraying operation.

Wind has more adverse effect on low-gallonage than on high-gallonage sprays.

See that spray reaches the lower as well as the upper surfaces of leaves; coverage of lower surfaces is especially important in control of the cabbage looper. Use three or five nozzles per row, preferably five when the plants are large and cabbage loopers are present. Direct the center nozzle downward into tops of plants, and other nozzles into the sides. The side nozzles should be on flexible drops, placed to give best coverage of the plants. When there are five nozzles per row, the lower pair should be as close to the ground as feasible, and directed slightly upward.

Equipment.—Rotary hand dusters, knapsack bellows-type dusters, or knapsack sprayers of the type that has an agitator and pump operated with a hand lever are suitable for use in small market gardens.

Power dusters operated by a gasoline engine or by power take-off from a tractor, and high-gallonage or low-gallonage power takeoff sprayers are suitable for large commercial plantings.

Low-pressure power sprayers maintain a pressure of 30 to 100 pounds per square inch and deliver 5 to 50 gallons of spray per acre. High-pressure sprayers maintain a pressure of 200 to 400 pounds per square inch and deliver 75 to 150 gallons or more of spray per acre.

Use of aircraft for applying insecticides is on the increase. Many commercial companies specialize in

TABLE 2.—*Dosages and examples of common formulations of insecticides to use for caterpillar control on cole crops*

Insecticide	Active ingredient per acre	Dusts		Sprays ¹	
		Strength at 25 pounds per acre	Formulation ²	Quantity per acre in 20 to 100 gallons of water	
<i>Bacillus thuringiensis.</i>	25 to 50 trillion viable spores.	5 billion spores per gram.	25 billion spores per gram WP. <i>or</i> 30 billion spores per gram AS ³ .	4 pounds.	
	27 to 54 trillion viable spores.	-----		2 to 3 quarts.	
DDT ⁴ -----	Pounds 1.25	Percent 5	50% WP----- <i>or</i> 2 pounds per gallon (25%) EC.	2½ pounds.	
Endosulfan-----	0.75	3	2 pounds per gallon EC.	5 pints.	
Naled-----	1 to 2	⁵ 4	8 pounds per gallon (64.5%) EC.	3 pints.	
Parathion ⁴ -----	0.5	2	15% WP----- <i>or</i> 2 pounds per gallon (25%) EC.	1 to 2 pints.	
Toxaphene ⁴ ---	3.2 to 4.0	⁶ 10 or 20	40% WP----- <i>or</i> 6 pounds per gallon (63%) EC.	3½ pounds.	
	⁷ 2.0 to 3.0	-----		1 quart.	
				8 to 10 pounds.	
				3 to 4 pints.	

¹ To obtain adequate coverage, you may need to add a wetting or sticking agent especially to high-gallonage, wettable-powder sprays. In using such additives, follow recommendations of the manufacturer.

² Wettable powder is designated as WP, emulsifiable concentrates as EC, and aqueous suspension as AS.

³ Containing 3 percent viable spores, by weight.

⁴ For application to the soil for cutworms, use 2 pounds of either DDT or toxaphene per acre. Mixtures of toxaphene with DDT or parathion, or of endosulfan with parathion, should provide the recommended dosages per acre of the active ingredients of both insecticides in the mixture. To reduce the danger of injury to the plants, only a wettable-powder formulation of DDT or parathion should be used in a low-gallonage spray containing an emulsifiable concentrate of toxaphene.

⁵ Apply a 4-percent naled dust at 25 to 50 pounds per acre.

⁶ Apply 30 to 40 pounds per acre of a 10-percent toxaphene dust or 15 to 20 pounds of a 20-percent toxaphene dust.

⁷ More than 2.5 pounds per acre may cause plant injury if applied in a low-gallonage emulsion spray.



TC-7037, TC-7039

Figure 21.—Equipment suitable for use in small market gardens: A, Rotary hand duster. B, Knapsack compressed-air sprayer.

aerial application. Application from the air is particularly advantageous when the soil is too wet to use ground equipment, when the plants are large and cover the soil surface, or when a large acreage must be treated quickly.

Use equipment that will get insecticide to all parts of the plants. Keep the equipment clean, making certain that corrosive materials such as naled are thoroughly removed from all parts of sprayers and dusters.

CULTURAL CONTROLS

The following practices help prevent caterpillar injury to cabbage plants and other cole crops:

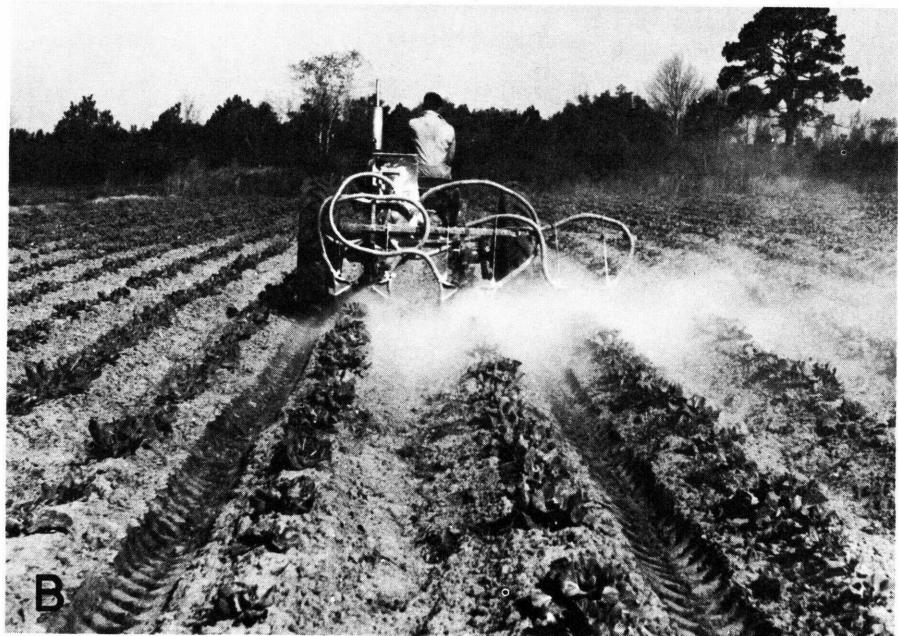
1. Transplant spring crops as

early as market and weather conditions permit.

2. Locate plantings as far as possible from older plants that are infested with caterpillars, especially those infested with larvae of the diamondback moth.

3. Harvest cabbage as soon as it is ready for market. As soon as possible after harvest, dispose of the unmarketable plants by plowing them under or by feeding them to livestock. See precaution on page 18.

4. Seed or transplant in rows of uniform width to permit effective use of spraying or dusting equipment. Space the plants uniformly along the row and far enough apart to prevent crowding. This makes it easier to apply an insecticide to all parts of the plant. Use enough



BN-20068, BN-20069

Figure 22.—Tractor-mounted dust machine suitable for applying an insecticide dust for control of caterpillars: A, With cloth hood over outlet nozzles to reduce drift of dust; B, same machine without cloth hood.

seed to insure an adequate stand, yet not so much that the young plants will be crowded before they are thinned or transplanted.

5. Thin or transplant to a nearly perfect stand of plants with sound terminal buds. Moderate insect injury to the terminal bud often disfigures the plant; severe injury may stop growth of the terminal bud.

6. Do not transplant or thin caterpillar-infested plants before using an insecticide.

7. Provide enough fertilizers, especially the nitrogenous ones, to keep the plants growing vigorously.

This will offset to some extent the effects of caterpillar feeding.

NATURAL CONTROLS

The number of caterpillars that attack cabbage and other cole crops may be appreciably reduced at times by other insects and by diseases, birds, and spiders. Natural controls, however, will not provide sufficient protection and little reliance should be placed on them in carrying on caterpillar-control programs.

COMMON AND SCIENTIFIC NAMES

Black cutworm-----	<i>Agrotis ipsilon</i>
Cabbage looper-----	<i>Trichoplusia ni</i>
Cabbage webworm-----	<i>Hellula rogatalis</i>
Corn earworm-----	<i>Heliothis zea</i>
Cross-striped cabbageworm-----	<i>Evergestis rimosalis</i>
Diamondback moth-----	<i>Plutella maculipennis</i>
Fall armyworm-----	<i>Spodoptera frugiperda</i>
Granulate cutworm-----	<i>Feltia subterranea</i>
Gulf white cabbageworm-----	<i>Ascia monuste</i>
Imported cabbageworm-----	<i>Pieris rapae</i>
Salt-marsh caterpillar-----	<i>Estigmene acrea</i>
Southern cabbageworm-----	<i>Pieris protodice</i>
Variegated cutworm-----	<i>Peridroma saucia</i>



This publication is intended for the commercial grower of cole crops in the South. For recommendations on the control of insects on these crops in the home gardens, see Home and Garden Bulletin No. 44, "Cabbage Insects—How To Control Them in the Home Garden."